

# The Development of Wage and Price Relationships for a Long-Term Econometric Model

IN September 1965, work was begun at Harvard University by Lester Thurow on the development of an econometric model designed to provide long-term projections of the U.S. economy and to aid in the formulation of fiscal policies. Financial support was provided by the Interagency Growth Project through a research contract with the Bureau of Economic Analysis (formerly the Office of Business Economics). A progress report on that work was published as "A Fiscal Policy Model of the United States," by Lester C. Thurow, in the June 1969 *SURVEY OF CURRENT BUSINESS*.

Since then, the model formulated by Thurow has been extensively tested and modified, but it retains its original features of relative simplicity and emphasis on Federal fiscal policies. The modified model (referred to in this article as the BEA long-term model) is currently being used to make long-term projections of GNP and its components.

Because of the emphasis on simplicity in the design of the original model, several important economic variables were treated at a highly aggregative level, compared to their treatment in other econometric models, and other variables that are usually treated as being simultaneously determined within the economic system represented by the econometric model were assumed to be exogenous.

Two key variables in an econometric model of the aggregate economy are the price level and the aggregate wage rate. In the original Thurow model, prices were exogenous and there was no equation for the wage rate. There was an

equation explaining employee compensation that was not so much a behavioral relationship based on theoretical considerations as a correlation of the movements of broad aggregates, since employee compensation was determined by observing its relatively constant ratio over time to national income.<sup>1</sup>

This treatment of employee compensation did not create a problem in the original version of the model since the only variable directly affected by employee compensation was social security contributions. Employee compensation did not interact at all with the supply side of the model. However, when the model was modified so that the income and supply sides interacted simultaneously, the reliability of the employee compensation equation became important.

Thus, a natural extension of the model is the development of a behavioral equation for compensation. Adopting the theory that prices and wages are simultaneously determined, an equation for the price level is also developed. This article reports on progress in the development of the compensation and price equations.

A three equation model is developed: an equation explaining the percent change in employee compensation per

man-hour, and two price relationships, the first explaining the level of the implicit deflator for gross private product and the second explaining the percent change in the implicit deflator for personal consumption expenditures.

The percent change in employee compensation per man-hour is explained primarily by two factors: demand pull, measured by the unemployment rate, and the expected rate of price change, measured by the percent change in the current period in the personal consumption expenditures deflator.

The percent change in the personal consumption deflator, needed for the compensation equation, is explained by a simple correlation with the percent change in the gross private product deflator, and that deflator is explained by making it a function of unit labor costs and a demand variable, the unemployment rate.

Development of wage-price relationships for the BEA long-term model started with an examination of wage behavior with respect to the unemployment rate, as in "Phillips curve" analysis. George Perry's findings concerning the effects of changes in labor force composition<sup>2</sup> were incorporated and tested, and a test was also made of a form of the price expectations hypothesis used in several recent studies.<sup>3</sup>

1. The Thurow model related employee compensation to an income variable consisting of personal income less the sum of dividends, interest (government and consumer), and government transfers. In the BEA long-term model, the equation has been modified to take the following form (fitted to annual data in current dollars for 1948-1966):

$$C = 23.84 + .7610Y \quad R^2 = .999 \\ (3.65) \quad (127.3)$$

C = private employee compensation

Y = gross national product less the sum of capital consumption allowances and indirect business taxes; values in parentheses are t ratios.

2. George L. Perry, "Inflation and Unemployment," in *Savings and Residential Financing: 1970 Conference Proceedings*, sponsored by the United States Savings and Loan League, Chicago, Ill., May 7 and 8, 1970; reprinted by the Brookings Institution, Reprint No. 188, Dec. 1970; "Changing Labor Markets and Inflation," in Okun and Perry, eds., *Brookings Papers on Economic Activity*, 3:1970, pp. 411-441.

3. See, e.g., E. J. Gordon, "The Recent Acceleration of Inflation and Its Lessons for the Future," in Okun and Perry, eds., *Brookings Papers on Economic Activity*, 1:1970, pp. 3-41. Gordon reports tests of the "acceleration hypothesis" in which an attempt to hold unemployment below the "natural" rate is hypothesized to lead to an ever-accelerating inflation.

NOTE.—A version of this article was delivered at the American Statistical Association Annual Meetings, Montreal, Canada, August 1972.

## Wage Relationships

The theory of wage determination used here as a basis for statistical estimation explains wage movements primarily by two forces: demand pull and the expected rate of price change. Additional explanatory variables, as explained below, are also hypothesized to affect wage determination.

Demand pull is measured by a form of the unemployment rate and the expected rate of price change is measured by the actual observed rate of change of a price index of consumer purchases.

A consideration in choosing the variables to be included in the wage equation was the desire to minimize the number of additional exogenous variables introduced into the model. The basic wage equation explains the percent change in employee compensation per man-hour by the reciprocal of the unemployment rate, the percent change in the deflator for personal consumption expenditures (PCE), the percent change in a corporate profit rate, the percent change in employee and employer social insurance contributions per man-hour, and the percent change in a variable representing industry mix. (The precise definitions of these variables are presented below, under the heading "Definition of variables.") The only variable exogenous to the model that is added in this formulation is the variable that measures change in the industrial composition of employment. Social insurance contributions and the corporate profit rate are endogenously determined in the original model, and the deflator for personal consumption expenditures is the dependent variable in one of the price equations developed in this study.

The unemployment rate is used as a measure of demand for labor. The reciprocal of the rate is specified to allow for the nonlinearity of the relationship between wage change and unemployment (a relationship that has generally been hypothesized to be convex to the origin when the rate of wage change is plotted against the unemployment rate).

The percent change in the PCE deflator is used as a measure of expect-

tations of future price changes. Use of only the current value of the variable (i.e., change from the previous to the current year) represents the assumption that price expectations are based only on current, not lagged, price movements.<sup>4</sup> The consumer price index (CPI) is the variable most frequently used in measures of price expectations in wage equations. However, its use here would present a problem in integrating the wage-price sector into the BEA long-term model. The planned dependent variable in the main price equation is the private GNP deflator, and the PCE deflator is better correlated with it than is the CPI. This consideration, plus the need for the PCE deflator elsewhere in the model, makes it preferable to use the PCE deflator rather than the CPI in constructing the price expectations variable.

The percent change in the profit rate is used as a measure of change in employers' ability to pay wage increases; or alternatively, it can be viewed as a measure of productivity change.<sup>5</sup>

The percent change in social insurance contributions appears as an explanatory variable because such contributions are included in the compensation measure that is being explained, and have shown marked variations over time because of changes in social insurance tax rates.<sup>6</sup>

Since wage levels as well as rates of wage change vary among industries, the ideal approach would be to estimate separate industry wage equations and then aggregate. Instead, as a simpler procedure an industry shift variable has been included. Since compensation per man-hour is relatively low in the service industries and since there has

been continuing employment shift to these industries, the percent change in the ratio of employment in the service industries to total employment is used as the measure of changes in industry mix. Since the model is estimated on an annual basis, all data for estimation are on an annual basis. Percent changes are calculated from the previous year.

Several lag patterns on the explanatory variables were tested, especially in the construction of the price expectations variable, but none of the lagged variables had a significant coefficient and frequently the signs were wrong. These results contrast with most published quarterly results, where lags, especially in the price expectations variable, have significant coefficients and the expected sign. It is not unreasonable, however, for explanatory variable lags of a year or more to have no effect on the dependent variable in the annual equations estimated in this study.

## Alternative specifications of labor demand

Perry's hypothesis, referred to previously, is that an unemployment rate weighted by composition of the labor force, and the dispersion of the unemployed, provide a better measure of labor demand conditions for explaining wage change than does the conventional unemployment rate.<sup>7</sup> To test this, several regressions were run with these two variables substituted for the unemployment rate.

A weighted unemployment rate  $U^*$  was calculated for each year using Perry's definition, and the weights ( $I_i$ ) calculated by him:<sup>8</sup>

7. For a theoretical basis for Perry's dispersion hypothesis see G. C. Archibald, "The Phillips Curve and The Distribution of Unemployment," *American Economic Review*, May 1969, pp. 124-124.

8. Perry, "Changing Labor Markets and Inflation," op. cit., pp. 436-440. In principle, there is a different set of weights ( $I_i$ ) for the various age-sex classes in each time period. However, Perry found that the weights vary insignificantly over time and so used averages, which are also used here.  $I_i$  is defined as  $J_i/K_i$ , where  $J_i$  is the ratio of the average annual hours worked per employed person in the  $i$ th age-sex class to the average annual hours worked by employed males age 25-44, and  $K_i$  is the ratio of average hourly earnings of employed persons in the  $i$ th class to the average for males aged 25-44. The age breakdown is into four groups: 16-19, 20-24, 25-44, 45 and over. Each age group is broken down into male and female.

Data on unemployment ( $U$ ) and labor force ( $L$ ) used for the calculation were taken from the *Memorandum Report of the President*, April 1971, p. 204.

4. This assumption is consistent with Gordon's finding based on quarterly data, that price expectations as measured by a distributed lag of changes in the CPI are not influenced by lagged price changes running back more than four quarters: Gordon, op. cit., p. 37.

5. J. Vandervamp, "Wage Adjustment, Productivity and Price Change Expectations," *Review of Economic Studies*, Vol. 39(2) No. 117 (January 1972), p. 62.

6. Alternatively, the dependent variable could have been calculated net of social insurance contributions, eliminating any need to include contributions as an explanatory variable. Preliminary results from this formulation are not encouraging but further testing is being carried out.

$$U^* = \frac{\sum I_i V_i}{\sum I_i L_i}$$

where:

- $I_i$  is the weight for the  $i^{\text{th}}$  age-sex class,  
 $V_i$  is the number in the  $i^{\text{th}}$  age-sex class who are unemployed,  
 $L_i$  is the number in the  $i^{\text{th}}$  age-sex class who are in the labor force,  
 and the summations are over all age-sex classes.

A measure of unemployment dispersion  $DU^*$  was calculated for each year using Perry's definition and the same data used in calculating the weighted unemployment rate:<sup>2</sup>

$$DU^* = \sum \left| \frac{I_i V_i}{\sum I_i V_i} - \frac{I_i L_i}{\sum I_i L_i} \right|$$

with the summations over all age-sex classes. This measure is the sum, over all age-sex classes, of the differences (without regard to sign) between the share of a class in total unemployment and its share in total labor force; all data are weighted by the weights ( $I_i$ ) described above. Perry's results showed that the pressure on wages would be greater as the value of the dispersion measure increased.

2. Perry, *ibid.*, p. 422.

### Plan of work

The plan for determining the wage equation to incorporate into the BEA long-term model was first to test equations using single equation estimating techniques; then, having selected a preferred equation on the basis of those tests, to estimate the equation for inclusion into the model, using simultaneous equation techniques. The final step was to simulate the period 1948-1968 using the model including the new compensation equation, as well as the new price equations developed in this article, and to compare these simulation results with those obtained prior to the equation change. (The simulation results presented at the end of this article are for simulations including not only the compensation equation selected for the model but also the two price equations developed in this article.)

### Definition of variables

$C$ : Private employee compensation per man-hour.

$U$ : Reciprocal of overall unemployment rate (percent).

$U^*$ : Reciprocal of weighted unemployment rate; calculation of weighted rate is described in text.

$DU^*$ : Measure of unemployment dispersion; calculation is described in text.

$P_1$ : Implicit price deflator for personal consumption expenditures (1958=100).

$P_2$ : Consumer price index (1958=100).

$P_3$ : Implicit price deflator for gross private product (1958=100).

$\Pi$ : Ratio of after-tax corporate profits to previous year's gross stock of nonresidential fixed capital in 1958 dollars.

$S$ : Ratio of employer, employee, and self-employed contributions for OASDI per man-hour.

$I$ : Ratio of the average number of employees (both full- and part-time) in service industries to the average number of full- and part-time employees in the total private economy. (Service industries are those defined as "Services" in *Standard Industrial Classification Manual*, 1972.)

$D_k$ : Dummy variable for Korean War Period; equal to 1 for 1951-53.

Table 1.—Equations for Change in Compensation Per Man-hour

Equation	$\hat{P}_1$	$\hat{P}_2$	$U^*$	$DU^*$	$U$	$\hat{\Pi}$	$\hat{S}$	$\hat{I}$	$D_k$	$D_e$	Constant	$e_{90}$	$e_{91}$	SEE	$\bar{R}^2$	DW
1	0.824 (0.54)		10.496 (1.09)	-0.0075 (.192)		0.0302 (3.34)	0.0301 (2.15)	-0.355 (1.91)	0.422 (.318)	-0.343 (.499)	1.579 (1.44)			0.706	0.92	1.93
2	.849 (.67)		12.401 (3.74)	-0.0280 (1.14)		.0314 (2.44)	.0327 (2.94)	-.349 (3.38)			1.478 (1.53)			.716	.92	1.94
3	.814 (.723)				14.633 (3.39)	.0318 (2.34)	.0328 (2.36)	-.395 (2.50)	-.087 (.108)	-.171 (.369)	1.061 (.910)			.728	.92	1.95
4	.823 (.828)				14.900 (4.08)	.0311 (2.46)	.0345 (2.92)	-.367 (3.50)			.858 (.838)			.885	.89	1.94
5		.909 (5.48)	13.860 (3.63)	-.0311 (1.33)		.0284 (2.07)	.0375 (2.66)	-.413 (3.30)			1.306 (1.74)			.814	.96	2.00
6		.877 (7.04)			15.154 (3.97)	.0283 (2.18)	.0404 (3.01)	-.407 (3.45)			.990 (.912)			.773	.91	2.00
7	.840 (6.94)		12.221 (2.29)	-.0158 (.504)		.0303 (2.36)	.0330 (2.51)	-.372 (3.31)			1.338 (1.37)	-.406	-.146	.613	.62	1.80
8	.840 (7.04)		11.024 (2.68)			.0296 (2.37)	.0388 (2.88)	-.367 (3.49)			1.300 (1.37)	-.026	-.391	.735	.92	1.81
9	.840 (7.27)				14.960 (3.76)	.0203 (2.47)	.0343 (2.73)	-.369 (3.35)			.839 (.816)	-.508	-.150	.716	.93	1.70
10	.831 (6.75)				14.968 (3.44)	.0280 (2.08)	.0363 (2.18)	-.373 (3.04)			.866 (.754)	-.491	-.160	.780	.92	1.80

NOTE.— $\bar{R}^2$  is the coefficient of determination corrected for degrees of freedom. Values in parentheses are t ratios, DW is the Durbin-Watson statistic, and SEE is the standard error of estimate corrected for degrees of freedom.

Dependent variable in each equation is  $\hat{C}$ .

Equations (1)-(9) were estimated by ordinary least squares; equation (10) is equation (9) estimated by two-stage least squares.

Equations (1)-(6) were estimated for 1948-1970; (7)-(10) were estimated for 1948-1968. Forecast errors for 1969 and 1970 are labeled  $e_{90}$  and  $e_{91}$  respectively.

$D_t$ : Dummy variable for period of wage-price "guideposts"; equal to 1 for 1962-66.

ULC: Unit labor cost (ratio of private employee compensation to private GNP in 1958 dollars).

Percent change from previous to current year is denoted by a dot over the variable.

### Estimated equations

Table 1 shows results of fitting various specifications of the wage equations. The dependent variable in each case is the percent change in compensation per manhour. Equations (1) through (6) were estimated for the period 1948-70; those which seemed to give the best results were then estimated for the period 1948-68, which is the period currently used for all other equations in the BEA long-term model. The equations estimated for 1948-68, numbers (7) through (10), were then used to forecast values for 1969 and 1970. This forecast provided another criterion on which to select a final equation specification for two-stage least squares estimation. The specification finally selected is the one shown as (4) fitted to 1948-70, and as (9) fitted to 1948-68.

Equation (1) incorporates Perry's hypotheses. The fit is very good but the coefficient of the dispersion variable,  $DU^*$ , has the wrong sign and is not statistically significant. Neither of the dummy variables, one for the Korean War period in which there were wage-price controls, the other for the 1962-66 "guidepost" period, has a significant coefficient.

Equation (2) is the same as (1) but with the dummy variables omitted. The fit is good with all coefficients having the expected sign except that of  $DU^*$ , which is again negative and not significant.

In equations (3) and (4) the variables  $U^*$  and  $DU^*$  are replaced with the conventional unemployment rate. The coefficients of the dummy variables used in (3) are again not significant but the coefficients of all other variables in both

equations have the expected sign and are statistically significant.

In each of these equations the coefficient of the price expectations variable is above 0.8. This value is much higher than those reported by most other studies,<sup>10</sup> although it does not support the accelerationist hypothesis since it is less than one. The high value is entirely due to the use of the PCE deflator rather than the CPI; this can be seen by comparing equations (2) and (4) with equations (5) and (6), where the only difference is the substitution of  $P_t$  for  $P_t^e$ .

Since equations (2) and (4) provide equally good explanations of the dependent variable, they were both re-estimated for the 1948-1968 period and appear as equations (7) and (9), respectively. Forecast errors for 1969 and 1970 are shown for these equations. The errors are calculated for both years using actual values of the independent variables. The equations over-predicted in both years; i.e., the actual change in compensation per manhour was smaller than predicted by the equations. Equation (8), which includes the weighted unemployment rate but excludes the dispersion index, was also estimated for the period 1948-68, and errors were calculated for 1969 and 1970.

Equation (9) is marginally better than (7) or (8) in terms of fit and forecast, and it also avoids the introduction of additional exogenous variables, compared to (7) and (8); thus, (9) was selected for estimation by the two-stage least squares method. The result is shown as equation (10).

The two-stage least squares procedure is used to circumvent simultaneous equation bias.<sup>11</sup> Two of the right-hand-side variables in the equation,  $\hat{\Pi}$  and  $\hat{S}$ , are determined simultaneously in the model with the percent change in employee compensation, the dependent variable. In two-stage least squares estimation, the actual

values of  $\hat{\Pi}$  and  $\hat{S}$  are replaced by values computed for them from ordinary least squares regressions applied to the reduced form of the complete BEA long-term model. Comparison of equations (9) and (10) shows that coefficients estimated by the two-stage procedure are very close to those estimated by ordinary least squares.

Since none of the equations presented here shows the weighted unemployment rate together with the dispersion measure to be superior to the conventional unemployment rate in the explanation of wage change, a further direct comparison was made, consistent with Perry's reported equations.<sup>12</sup> Two equations were estimated, identical except for the unemployment concept. The profit rate is omitted from the explanatory variables because it is not included in Perry's regressions. The interindustry shift variable is included, however, since Perry adjusted his dependent variable to take account of employment shifts among industries. Using symbols already defined, the regression results for 1948-70 are:

$$(a) \dot{C} = 2.17 + .546 \dot{P}_t + 12.42 U^* \\ (1.94) \quad (5.63) \quad (3.08) \\ - .0287 DU^* + .0439 \hat{S} \\ (1.13) \quad (2.94) \\ - .459 \hat{\Pi} \\ (3.42)$$

$$\bar{R}^2 = .88, DW = 2.46, \overline{SEE} = .764$$

$$(b) \dot{C} = 1.40 + .522 \dot{P}_t + 14.87 U + \\ (1.19) \quad (6.10) \quad (3.36) \\ .0482 \hat{S} - .452 \hat{\Pi} \\ (3.23) \quad (3.54)$$

$$\bar{R}^2 = .89, DW = 2.47, \overline{SEE} = .750$$

By the usual measures equation (a) would not be considered superior in any respect to equation (b). This finding differs substantially from Perry's finding that  $U^*$  provides more explanatory power than  $U$ . Perry's study used quarterly data; however, since changes in labor force composition occur only gradually over time, this factor, if relevant, should retain its explanatory power in an annual compensation equation.

10. See e.g., Gordon, *op. cit.*, p. 17, and Perry, "Changing Labor Markets and Inflation," *op. cit.*, p. 428.

11. For a complete discussion of simultaneous equation bias in ordinary least squares estimation, and an explanation of two-stage least squares, see A. S. Goldberger, *Econometric Theory*, New York: John Wiley and Sons, 1964, pp. 298-334 and pp. 320-334.

12. Perry, "Changing Labor Markets and Inflation," *op. cit.*, p. 428.

# Price Relationships

To close the wage-price sector it is necessary to develop an equation explaining the implicit deflator for personal consumption expenditures. The price deflators for all major final demand components as well as the deflator for private GNP are required by the BEA long-term model. Two methods of making these prices endogenous are available: (1) the component deflators can be estimated and then aggregated to derive the overall deflator; (2) the overall deflator can be estimated first and the component deflators can be based on it by means of simple regressions. Method (2) will produce one more equation than the number of deflators to be determined, since the overall deflator is a weighted average of the components; this problem of over-determination can be solved by replacing the initial value of the private GNP deflator, as calculated from its equation, by the weighted average of the component deflators. Because method (2) is considerably easier from the point of view of statistical estimation, it was selected.

The relationship hypothesized to explain the private GNP deflator is that it is a mark-up over unit labor cost, with the mark-up varying as aggregate demand fluctuates.<sup>13</sup>

In the equation used, unit labor costs have a delayed effect on prices, reflecting transmission lags, while fluctuations in aggregate demand, as measured by the unemployment rate, are assumed to affect the price level concurrently. Since the model is estimated with annual data, a lag of one period means a lag of one year. The equation, fitted to annual data for 1948-68, is:

$$(11) \hat{P}_3(t) = 16.4 + (6.2) \\ 172.5 \text{ ULC}(t-1) - 1.256 \text{ U}(t) \\ (34.5) \quad (4.4)$$

$\bar{R}^2 = .98$ ,  $DW = 1.84$ ,  $SEE = 1.33$ , numbers in parentheses are *t* ratios.

The coefficients of both explanatory variables have the expected sign and are significant. The elasticity of the private GNP deflator with respect to unit labor costs, calculated at the variable means, is 0.90. This seems to be in line with previously reported elasticities,<sup>14</sup> but the fact that it is less than unity implies a slight increase in labor share over time. Forecast values of the private GNP deflator for 1969 and 1970 are 123.6 and 129.9, respectively, an underprediction in both years. The 1969 forecast error is 0.7 index point and the 1970 error is 0.4 point.

The estimated equation tying the deflator for personal consumption expenditures ( $P_1$ ) to the private GNP deflator ( $P_3$ ), expressed in terms of percentage changes and fitted to annual data for 1948-68, is:

$$(12) \hat{P}_1 = .124 + .857 \hat{P}_3 \\ (1.49) (22.7)$$

$\bar{R}^2 = .97$ ,  $DW = 1.80$ ,  $SEE = .31$ ; numbers in parentheses are *t* ratios.

The variables have been defined previously. The equation was corrected for serial correlation by the Cochrane-Orcutt procedure.<sup>15</sup>

Forecast values for the PCE deflator were calculated for 1969 and 1970,

using the actual value of the independent variable in both years and applying the predicted percent change to the actual value of the PCE deflator in 1968 and 1969, respectively. The 1969 forecast implied a PCE deflator of 123.4 in that year, compared to an actual value of 123.5. The 1970 forecast implied a PCE deflator of 129.1, compared to 129.3 actual.

# Simulation Results

Equation (10), the two-stage estimation of the preferred compensation equation, and the equations for the PCE and private GNP deflators, were used with the full BEA long-term model to simulate the complete set of endogenous variables for the period 1948-68 and to forecast these variables for 1969. Annual absolute errors between estimated and actual values of some of the endogenous variables were then calculated and compared with errors calculated from a model simulation for the same time period before equation (10) was substituted for the compensation equation previously used and before the addition of the two deflator equations. Average annual absolute errors, calculated as percentages of actual values, are shown in table 2 for simulation before and after the inclusion of equations (10) through (12).

The increased error in simulating nonresidential fixed investment can be traced to a poor corporate profits equation. Simulations of both private GNP and personal consumption expenditures show improved results, the latter resulting from a significantly

14. For example, R. J. Gordon in "Inflation in Recession and Recovery" *Brookings Papers on Economic Activity* 1:1970, p. 128, reports an elasticity value of unity on standard unit labor costs.

15. For a description of this procedure, see D. Cochrane and G. H. Orcutt, "Application of Least Squares Regressions to Relationships Containing Autocorrelated Error Terms," *Journal of the American Statistical Association*, vol. 44, March 1949, pp. 32-61.

Table 2.—Simulation Errors

Variable	Average annual percent error without regard to sign, 1948-1968	
	Without equations (10) through (12)	Equations (10) through (12) included
Gross private product (1968\$).....	1.7	1.6
Nonresidential fixed investment (1968\$).....	3.8	4.8
Personal consumption expenditures (1968\$).....	1.28	1.0
Disposable personal income (1968\$).....	1.4	0.6
Private employee compensation.....	1.9	1.7
PCE deflator.....	(*)	1.6
Private GNP deflator.....	(*)	1.1

\* Exogenous.

13. This hypothesis can be shown to be consistent with the form of the production function specified elsewhere in the BEA long-term model.

smaller error in disposable personal income. All three new equations perform well. However, the 1969 forecast error for the PCE deflator is larger in the full model simulation than when the forecast is made by single equation. The PCE deflator forecast by the full model for 1969 is 124.7 compared to 123.5 actual. Using the full model, the forecast of the private GNP deflator is 124.8 in 1969, compared to an actual value for that year of 124.3.

### Summary

A three-equation model of the wage-price sector has been developed and integrated into the BEA long-term

model. Changes in the unemployment rate and in the price expectations variable were found to have the largest impact on changes in compensation per manhour. Although the value of the coefficient of the price expectations variable in the compensation equation is high, there does not seem to be support for the accelerationist hypothesis. Neither labor force composition change nor dispersion of the unemployed over age-sex classes provides additional explanatory power for change in compensation, contrary to recent empirical work. The coefficients of lagged unit labor cost and the current unemployment rate in the

equation for the gross private product deflator were significant, and this formulation of the markup hypothesis produced a good fit over the sample period.

The wage and price equations were integrated into the BEA long-term model and the model was simulated for the sample period, to make error comparisons of that simulation with a simulation made without the new equations. The results are encouraging, but work on evaluating forecast errors beyond the sample period must be carried out to evaluate fully the contribution to the model of the new relationships.

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